Prospective Study

Contrast Dispersion Pattern and Efficacy of Computed Tomography-Guided Cervical Transforaminal Epidural Steroid Injection

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Background: The causes of upper extremity radicular pain or neck pain are varied, often involving disc herniation, spinal stenosis, or spondylosis. Cervical transformaminal epidural steroid injection (C-TFESI) is a common treatment for such pain. However, its efficacy conceivably may depend on needle-tip placement, linking the degree of pain reduction achieved to the pattern of contrast dispersion.

Objective: The current study explores this relationship, evaluating contrast dispersion patterns of C-TFESI in conjunction with short-term patient outcomes.

Study Design: Prospective evaluation.

Methods: A total of 67 patients with cervical radicular pain were enrolled, each of whom underwent computed tomography (CT)-guided C-TFESI. Procedural contrast dispersion was judged as either intraforaminal or extraforaminal. Using the Roland 5-point pain scale, outcomes were scored 2 weeks after injection and then grouped as improvement (scores, 0 – 2) or no improvement (scores, 3 – 5).

Results: Contrast dispersion was largely intraforaminal (50 patients), as opposed to extraforaminal (17 patients), with no statistically significant difference in short-term pain relief by contrast pattern (intraforaminal: 56%, 28/50; extraforaminal: 53%, 9/17; $P = 0.459$). Of the 50 procedures where dispersion of contrast was intraforaminal, 44% (22/50) were scored as unfavorable outcomes.

Limitations: Small sample size, brief follow-up, and secondary outcomes were not measured. Authors also did not analyze other variables impacting C-TFESI, and classifying patterns of contrast spread anatomically as epidural or epiradicular (one, both, or neither as applicable) is simply not feasible by CT.

Conclusion: C-TFESI is an effective treatment for cervical radicular pain that is refractory to conventional conservative remedies. However, therapeutic response to C-TFESI and dispersion pattern of injected contrast failed to correlate in this study.

Key words: Cervical, epidural, contrast, CT-guided, TFESI

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Upper extremity radicular pain or neck pain has many causes, including disc herniation, spinal stenosis, and spondylosis. Cervical transformaminal epidural steroid injection (C-TFESI) is a common treatment for such pain (1-4). Cyteval et al (5) reported good-to-excellent pain relief 2 weeks after C-TFESI in 18 of 30 patients, with a sharp drop in average scores (from 6.3 to 1.2) by visual analogue scale. Similarly, 60% of patients studied by Slipman et al (6) registered good or excellent results with C-TFESI after an average follow-up of 21 months.

Some authors have reported that computed tomography (CT)-guided C-TFESI through a posterior approach is safe and effective and is more effective than a C-arm guided procedure with respect to reducing pain and improving functional status in instances of cervical disc herniation (3,4). C-arm fluoroscopy is relatively inexpensive and is easy to apply, but has the

disadvantages disadvantages, this procedure depends solely on bony anatomical landmarks (7). CT fluoroscopically guided injection provides excellent anatomical resolution and more precise needle placement in the axial plane. Detection and avoidance of important vascular structures (i.e., jugular, vertebral, and carotid vessels) are thus enabled during needle advancement into the outer neural foramen, facilitating meticulous needle delivery to the posterior aspect of the neural foramen (8,9). On the other hand, CT-guided procedures have been hampered by an inability to show the spread of contrast media in real time and by the need for expensive equipment. Furthermore, there have been no related studies of cost-effectiveness effect. Recently, high-resolution ultrasound has been used successfully to identify the tarfgeted nerves, neighboring blood vessels, and anatomic planes, and to permit real-time guidance of needle insertion, without exposure to radiation hazards (10). However, anatomic structures obscured by bony surfaces cannot be detected by ultrasound.

In theory, needle-tip placement has the potential to impact contrast dispersion during C-TFESI (1,11,12). Hoang et al (1) demonstrated that tip placement at the outer edge of the neural foramen (i.e., junctional location) is associated with intraforaminal dispersion of contrast during CT-guided cervical transforaminal steroid injection and correlates well with the distribution of injectate. Furthermore, with C-TFESI under ultrasound-guidance, contrast spread and tissue penetration patterns seemingly correspond with significantly better therapeutic outcomes (13). Medial and lateral foraminal dispersion especially may allow more steroid exposure at the source of pain (13,14). Nonetheless, given that contrast spread may differ in pattern for same-site needle placement by ultrasound, a link between pain relief and contrast dispersion is feasible.

To our knowledge, no prior published studies have examined the therapeutic response to CT-guided C-TFESI in terms of contrast patterns. The aim of the current study was to assess the relationship between contrast dispersion patterns of C-TFESI and short-term patient outcomes.

Methods

A total of 67 patients with cervical radicular pain were enrolled in this prospective study. Diagnosis was based on clinical symptoms, neurological examinations, and imaging studies, including plain radiography and magnetic resonance imaging (MRI) of the cervical spine. The study protocol was approved by our Institutional Review Board, and all patients granted written informed consent.

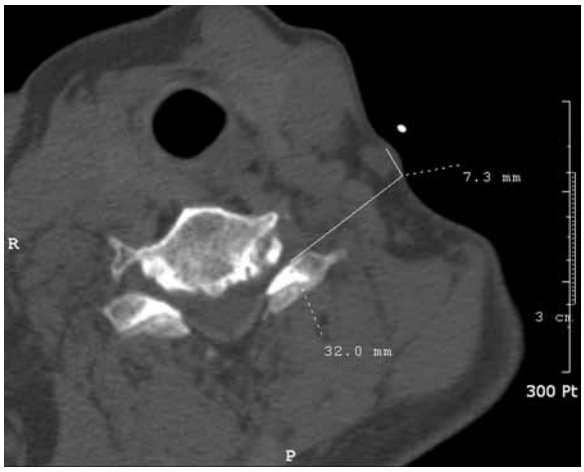
The principle inclusion criteria was cervical pain, qualified as follows: (1) radicular in nature; (2) refractory to more than 4 weeks of conservative treatment, namely physical therapy, chiropractic manipulation, exercises, drug therapy, and bed rest; (3) originating at a single spinal level; and (4) warranting MRI. Exclusion criteria were as follows: (1) ambiguity of described symptoms; (2) prior neck surgery; (3) unequivocal motor power weakness (strength less than grade IV); (4) symptoms of myelopathy; and (5) no MRI evidence of cerebrospinal fluid around cervical cord.

Each patient assumed the supine position for scanning (Philips Brilliance Big Bore, Andover, MA, USA), facing the side contralateral to the injection site, and a radiopaque skin marker was placed on the exposed lateral neck. A preliminary, unenhanced CT scan of the cervical spine was obtained through the area of interest for injection planning).

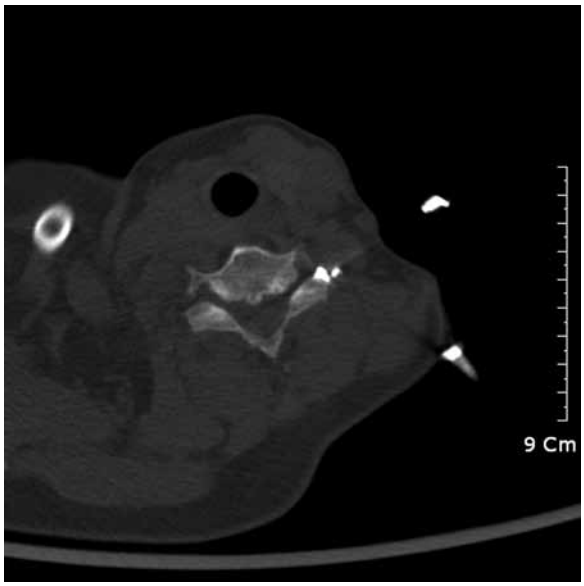
Thereafter, the skin was prepped, draped in sterile fashion, and anesthetized with 0.2% ropivacaine. Under intermittent CT fluoroscopy, a 22-gauge 3.5-inch needle was inserted percutaneously and advanced to the posterior aspect of neural foramen (bottom one-third), aiming for tip placement at or near the foraminal zone. An oblique line from the anterolateral vertebral body to the lateral margin of the facet was invoked, separating the foraminal and extraforaminal space. To qualify as locations, placement of the needle tip at this line was mandatory. Upon negative aspiration, 0.2 – 0.5 mL of contrast (iohexol) was slowly injected, with the bevel of needle directed ventrally. Given satisfactory contrast distribution, 2 mL of injectate (dexamethasone [5 mg/mL], 1 mL; ropivacaine [2.5 mg/mL], 0.5 mL; normal saline, 0.5 mL) was slowly instilled). C-arm fluoroscopy was not used for this study.

Contrast distribution was classified as either intraforaminal or extraforaminal (Figs. 1A, 1B, 2A, 2B). Outcomes were scored 2 weeks postprocedure, using the Roland 5-point pain scale (0, absence of pain; 1, little pain; 2, moderate pain; 3, severe pain; 4, very severe pain; and 5, almost unbearable pain). Patients were then grouped as those showing improvement (scores, 0 – 2) or no improvement (scores, 3 – 5).

A sample size of 67 was specified in advance to provide 80% power to detect a difference in the mean between treatments (G* power 3). The relationships between needle-tip location and contrast dispersion and between pain relief and contrast dispersion were as-

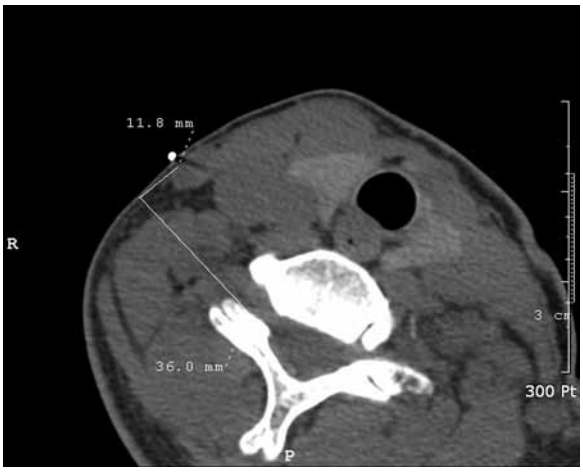


A

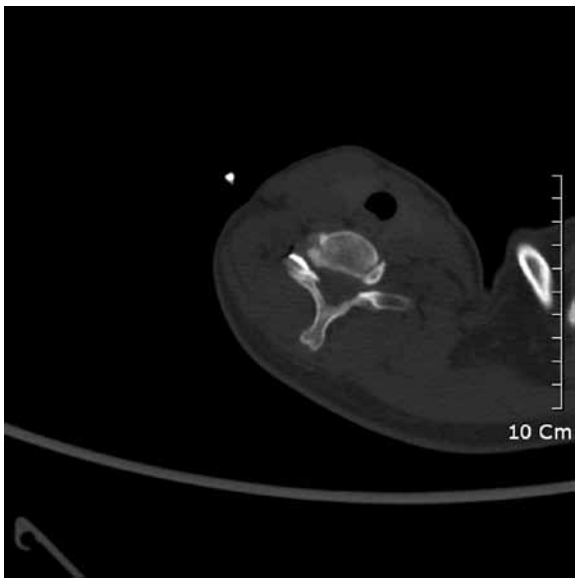


B

Fig 1. *Male (60 years old) during CT-guided C-TFESI of right C6 nerve root for radicular arm pain: (A) Preliminary projective line and (B) Extraforaminal contrast.*



A



B

Fig 2. *Female (46 years old) during CT-guided C-TFESI of right C6 nerve root for radicular arm pain: (A) Preliminary projective line and (B) Intraforaminal contrast.*

sessed by Chi-square and Fisher's exact test, respectively. All analyses relied on a standard software program (SPSS 13.0, Chicago, IL, USA), with statistical significance set at $P \leq 0.05$.

Results

Characteristics of the 67 patients (mean age, 53.8 years; men, 46) are summarized in Table 1. In Table 2, needle-tip locations, needle angles, and contrast distri-

Table 1. *Patient characteristics.*

N	67
Age (yr)	53.8 (10.5)
Gender (M:F)	46 : 21

Table 2. *Needle tip, depth, angle and contrast distribution.*

	C6 (n=31)	C7 (n=36)
Needle tip		
Foramen	14 (45.2%)	12 (33.3%)
Junction	17 (54.8%)	24 (66.7%)
Depth (cm)	3.3 (0.5)	3.3 (0.8)
Angle (degree)	39.6 (12.0)	36.1 (10.3)
Contrast pattern		
Intraformen	23 (74.2%)	27 (75.8%)
Extraforamen	8 (25.8%)	9 (24.2%)

Table 3. *Relationship between needle tip location and contrast pattern.*

	Contrast Pattern	
Needle Tip	Intraforamen	Extraforamen
Foramen (n=26)	25(50%)	1 (5.9%)
Junction (n=41)	25(50%)	16 (94.1%)
Total (N)	50	17

Table 4. *Relationship between contrast pattern and post-procedure at 2 weeks outcome.*

	Contrast Pattern	
Roland score	Intraforamen (n=50)	Extraforamen (n=17)
little pain	16 (32%)	4 (23.5%)
moderate pain	12 (24.0%)	5 (29.4%)
bad pain	5 (10.0%)	4 (23.5%)
very bad pain	17 (34.0%)	4 (23.5%)

butions by nerve root level are recorded for all C-TFESI procedures. Needle tip placement was either junctional, i.e., the needle tip is between intra-and extraforamen (41 patients, 61%) or foraminal (26 patients, 39%), with intraforaminal (50 patients) or extraforaminal (17 patients) dispersion of contrast.

Table 3 chronicles the relationship between needle-tip location and contrast dispersion. With the needle tip placed at the neural foramen, intraforaminal dispersion of contrast was almost assured (25/26, 96%). Intraforaminal contrast dispersion was also more apt to occur with junctional placement (25/41). The position of the needle and the contrast dispersion pattern correlated significantly (P = 0.004).

Therapeutic outcomes relative to the contrast dispersion pattern are logged in Table 4. Short-term pain relief did not differ significantly by contrast dispersion pattern (intraforaminal: 56%, 28/50; extraforaminal: 53%, 9/17; P = 0.459). Of the 50 procedures where dispersion of contrast was intraforaminal, 44% (22/50) were scored as unfavorable outcomes.

Discussion

The present study failed to demonstrate a correlation between contrast dispersion in C-TFESI and therapeutic outcome. Reductions in cervical pain achieved after CT-guided C-TFESI by the targeted delivery of medication (medial and lateral to neural foramen) bore no relationship to the corresponding patterns of contrast dispersion. This finding is inconsistent with previous studies (1,14).

Typically, pain relief is expected if contrast spread is medial to the neural foramen, implying the ready dispersion of medication to the source of pain (13); and such exposure is usually achieved by placement of the needle tip at the foramen. However, patients in this cohort also registered pain relief with extraforaminal contrast dispersion, indicating that direct access to the nerve root is not essential. Therapeutic injections may eventually reach the neural foramen, despite a lack of initial proximity to the nerve root. According to one study, mean pain reduction 20 – 30 min postprocedure was 38.4% in instances of indirect therapeutic injection, compared with 43.2% for direct injection (15).

Inflammation of spinal nerves may also cause neck and arm pain. Corticosteroids are known to reduce inflammation by inhibiting synthesis of various pro-inflammatory mediators (10). In addition to the anti-inflammatory effect of local anesthetics, short- to long-term symptomatic relief is conferred by way of diminished nociceptive discharge, sympathetic desensitization and reflex arc blockade, and inhibition of axonal transport in nerve fibers (16).

On another note, CT guidance offers significantly better clinical efficacy than C-arm guidance by providing better anatomic resolution and enabling more precise needle placement (3). Ultrasound imaging may facilitate delineation of vessels, but in comparing procedures done by C-arm and ultrasound guidance, no significant difference surfaced in terms of Neck Disability Index and Verbal Numeric Pain Scale at 2 and 12 weeks posttreatment (14). To minimize some of the

catastrophic complications of CT-guided C-TFESI, we used multislices to output a z-axis simultaneously with customary 2D imaging. Sequential 3-slice images of 4-mm thickness (12 mm at full thickness) were obtained by a single rotation of the gantry in from CT fluoroscopy, so the actual location of the needle was identifiable in all 3 planes.

In this study, dexamethasone was utilized exclusively as a steroid treatment in order to avoid serious side effects, namely brainstem or cerebellar infarcts. Particulate corticosteroids, such as methylprednisolone and triamcinolone, carry a risk of embolic infarction (17). And because our purpose was not to investigate the consequences of variable steroid dosing, only 5 mg of dexamethasone was routinely administered.

Each of our patients received a 2 mL transforaminal injection, with a mixture of ropivacaine 2.5 mg (of 0.5 mL), dexamethasone 5 mg (1 mL), and normal saline (0.5 mL). This volume of injectate is relatively large, considering roughly 0.5 to 0.6 mL required for a selective nerve block (18,19). Again, it was not our intent to assess efficacy as a function of differing injectate volumes. This larger volume of injectate was elected to assure adequate coverage of the ventral epidural space, where axial or radiating pain may originate due to inflammation or mechanical reaction.

There are clear limitations to the present study. Aside from the small sample size and brief follow-up interval, procedural outcomes were expressed as subjective patient-generated pain scores, and alternative treatment endpoints, such as functional status, medication requirements, and psychological effects, were not addressed. We also did not analyze other variables impacting C-TFESI, and classifying patterns of contrast spread anatomically as epidural or epiradicular (one, both, or neither as applicable) is simply not feasible by CT.

Conclusion

In conclusion, C-TFESI is an effective treatment for cervical radicular pain that is refractory to conventional conservative remedies. In the course of this study, however, no correlation was established between therapeutic response and contrast dispersion pattern.

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